

# 1 Developing Digital Comics to Enhance Landslide 2 Disaster Literacy among Elementary School Students

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8 <https://doi.org/10.17977/um065.v6.i9.2026.3>

## Article history

Submitted: 15 May 2026

Revised: 3 June 2026

Accepted: 7 June 2026

Published: 8 June 2026

## Keywords

ADDIE

Digital comics

Disaster literacy

Elementary schools

Landslide mitigation

## Abstract

This study's core research objective is to develop a digital comic themed on landslide disaster mitigation. The comic is targeted at fifth-grade primary school students in East Java, Indonesia, meets three preset criteria (learning validity, practicality, and effectiveness), and deeply integrates literacy related to landslide disaster risk reduction. This study adopts the research and development (R&D) method and advances all work in full compliance with the ADDIE five-phase research framework throughout the implementation process. Research data is collected through observation, interviews, questionnaires, and academic achievement tests. Core research tools include supporting instruments: expert validation forms, teacher-student response questionnaires, and pre-test and post-test assessment questions. All data processing is completed using descriptive quantitative analysis and N-Gain analysis. The final core outcomes show that the developed product received a score of 83% from media experts, 87% from teaching material experts, and 95% from frontline practitioners, which meets the requirements for high effectiveness. The 89% student response rate reaches the standard for high practicality. The average N-Gain value of 0.6 represents a moderate learning gain, which can improve students' academic performance, while also cultivating their learning motivation, active participation, and early-stage disaster prevention awareness.

## 9 1. Introduction

10 Hydrometeorological disasters, in recent years, have emerged as one of the most severe and widening  
11 hazards threatening Indonesia. The dominance of mountainous areas, high rainfall intensity and land use changes  
12 in various regions of Indonesia makes the potential for landslides a very high concern. Data from the National  
13 Disaster Management Agency has shown that landslides are one of the highest level disasters and life-  
14 threatening factors to human. Disaster incidents in Indonesia during the year 2024 were still dominated by  
15 hydrometeorological disasters, particularly landslides that caused casualties, destruction of residential areas,  
16 public facilities and education (Kurniawan & Nirmalasari, 2022; Kurniawati, 2020; Pahleviannur, 2019). This  
17 condition shows that disaster mitigation must be done in a systematic and sustainable way, not only through  
18 physical infrastructure but also by strengthening disaster education from an early age (Budi et al., 2026; Susilo  
19 et al., 2025; Suwaryo & Yuwono, 2017; Wu et al).

20 Disaster education are strategic measures that lead to a culture of preparedness, which sees effects on  
21 increasing community through awareness-raising about potential risks in the surrounding environment.  
22 Disaster literacy, particularly among elementary school-aged children is an urgent need because they are among  
23 the most vulnerable groups during disaster. Disaster literacy is not just knowledge about the types of disasters  
24 and what causes disasters, but also includes being able to recognize warning signs, understand mitigation  
25 measures, and make appropriate decisions in emergency situations (Afrian 2019; Cecep & Permana 2011;  
26 Labudasari & Rochmah 2020). Increasing disaster literacy for elementary school students is necessary because  
27 in the concrete operational stage of development, students more easily understand the material by experiencing  
28 visual images, stories and contextual learning (Asrizal & Festiyed, 2020; Manek, 2023; Reza et al., 2024; Wilujeng  
29 & Sukarni, 2022).

30 However, the implementation of disaster mitigation education in elementary schools still faces various  
31 challenges. Disaster education generally remains focused on lecture-based methods and the use of theoretical  
32 textbooks, making it less effective at providing meaningful learning experiences for students. Disaster mitigation  
33 material is also often presented in a fragmented manner without connecting it to real-world conditions in the  
34 students' immediate surroundings. As a result, students tend to struggle to understand concrete and practical  
35 disaster mitigation steps. Furthermore, the lack of innovative learning media makes disaster education less

36 engaging and fails to optimally enhance student engagement and preparedness. Yet, elementary school students  
37 typically grasp material more easily through visual media and interactive activities (Genika et al., 2023; Wibowo  
38 et al., 2017). Other studies also indicate that disaster mitigation education in elementary schools has yet to  
39 widely adopt contextual learning models and media, resulting in students' understanding of disaster mitigation  
40 remaining suboptimal (Noviana et al., 2023; Salsabila & Dinda, 2021; Sih & Kirana, 2016; Xiao et al., 2026)

41 Advances in digital technology offer opportunities to develop learning materials that are more innovative,  
42 engaging, and tailored to the characteristics of 21st-century learners. One medium with great potential for use  
43 in disaster education is the digital comic. Digital comics are technology-based visual learning materials that  
44 combine illustrations, text, color, and storytelling in an electronic format, thereby creating a learning experience  
45 that is both enjoyable and easy to understand. The use of digital comics is considered effective in helping  
46 students understand abstract concepts through visualization and contextual narratives. Various studies indicate  
47 that digital comics can enhance learning motivation, reading interest, student engagement, and conceptual  
48 understanding more effectively than conventional media (Galan, 2015; Hidayati et al., 2024; Khotimah &  
49 Hidayat, 2022). Furthermore, visual story-based media is considered capable of strengthening memory and  
50 helping students understand real-world situations related to disaster mitigation (Akgün & Akgün, 2020).

51 Several previous studies have developed digital comics for use in various learning contexts. Previous  
52 research indicates that digital comics are effective in improving students' learning outcomes and thinking skills  
53 (Jannah & Sandika, 2023; Khotimah & Hidayat, 2022). Other studies have also found that disaster-based visual  
54 media can increase students' preparedness for potential disasters in their surrounding environment  
55 (Mahamood et al., 2024; Rasmiet et al., 2025). Nevertheless, a review of the literature indicates that research on  
56 the development of digital comics for disaster mitigation education still has several limitations. Most previous  
57 studies have focused primarily on earthquake and flood mitigation (Aprianti & Nadiyyah, 2024; Johnson et al.,  
58 2014), whereas the development of digital media specifically addressing landslide mitigation for elementary  
59 school students remains relatively limited. Furthermore, previous studies generally emphasized only the visual  
60 and interactive aspects of the media without systematically integrating disaster literacy into the learning  
61 narrative. The media developed have also not been designed based on the cognitive developmental  
62 characteristics of elementary school students, so aspects of risk understanding and preparedness have not been  
63 the primary focus in the development of disaster education media.

64 Given these issues, there is a research gap in the development of disaster education materials capable of  
65 integrating disaster literacy, digital technology, and the characteristics of elementary school students into a  
66 single contextual and interactive educational product. Therefore, the novelty of this study lies in the  
67 development of a digital comic integrating disaster literacy based on the ADDIE model (Analysis, Design,  
68 Development, Implementation, and Evaluation) for landslide mitigation education in elementary schools. Unlike  
69 previous studies, the digital comic developed here serves not only as a visual learning medium (Hosler &  
70 Boomer, 2011) but is also designed to build students' ability to recognize landslide risks, understand mitigation  
71 steps, make decisions in emergency situations, and foster preparedness through a contextual storytelling  
72 approach closely tied to students' daily lives. The integration of disaster literacy into the narrative of the digital  
73 comic is the key distinguishing feature of this study, as the learning process emphasizes not only cognitive  
74 aspects but also the early development of students' disaster awareness and response capabilities.

75 The ADDIE model was selected in this study due to its structured yet adaptable stages, making it  
76 appropriate for developing digital instructional media. The model consists of five phases about analysis, design,  
77 development, implementation, and evaluation, which guide the development process systematically to produce  
78 learning media that are valid, practical, and effective for classroom use (Molenda, 2003). Based on this  
79 framework, the present study focuses on developing a digital comic integrated with disaster literacy content on  
80 landslide mitigation for elementary school students. By utilizing engaging visual stories, the developed media  
81 helps students understand disaster mitigation concepts more easily and contextual learning experiences. In  
82 addition, the integration of disaster literacy is expected to foster students' awareness, preparedness, and  
83 responsiveness toward potential landslide disasters in their environment. A developmental approach is  
84 employed to innovate digital disaster education media at the elementary school level, which is expected to  
85 provide useful contributions and become a reference for further studies.

## 86 2. Method

87 This research is an R&D concerning for making of a digital comic that combines disaster literacy into  
88 landslide mitigation learning in elementary schools. To ensure a systematic yet flexible process, this research  
89 employs the ADDIE development model, which comprises five core stages: Analysis, which identifies learning  
90 needs and learner characteristics; Design, which develops the instructional plan and product blueprint;  
91 Development, which involves product creation, validation, and revision; Implementation, which tests the  
92 product in the learning environment; and Evaluation, which assesses the effectiveness and quality of the  
93 developed product for further improvement (Molenda, 2003). These stages are particularly well-suited for  
94 creating digital learning media.

95 After the analysis phase profile of learning needs, student characteristics, landslide mitigation materials  
 96 and disaster education conditions in elementary schools. Following the storyline of the digital comic, media  
 97 interface, disaster literacy integration, content development and research instruments were prepared during  
 98 the design phase. The developed digital comic was created based on the design plan and then validated by media  
 99 experts, material experts, and language experts to examine its feasibility and quality. In the implementation  
 100 stage were carried out trials of activities with elementary school students to measure the practicality and  
 101 effectiveness of learning media in classrooms. The last step of the development process was evaluation, which  
 102 aimed to examine the overall process and revise the product based on suggestions from experts and results from  
 103 trials.

104 The Study was undertaken at an elementary school in East Java Qualitative and Quantitative data were  
 105 used in this research. With qualitative data includes opinions, suggestions, appraisals and responses of  
 106 validators and users on digital comics developed. For quantitative responses, however, were obtained from  
 107 expert validation scores as well as teacher and student questionnaire results as well students test scores in  
 108 relation to their understanding of landslide mitigation material. Different methods were used to collect the data,  
 109 including observations, interviews, questionnaires and tests. Required and barriers to disaster mitigation  
 110 learning at the elementary school level were identified through observations as well as interviews.  
 111 Questionnaires were given to assess the validity, practicality and user perceptions of media developed for  
 112 learning. We also conducted tests to assess students' understanding of landslide mitigation concepts after  
 113 engaging with the digital comic. Research tools used a four-point Likert scale with categories: (1) very poor  
 114 situation, (2) poor situation, (3) good situation and (4) very good situation. The resultant validation was  
 115 interpreted quantitatively descriptively by taking the percentage level of product feasibility with the following  
 116 formula. The validity of the developed product was determined based on the criteria presented in Table 1.

$$117 \quad P = \frac{\sum X}{\sum Xi} \times 100\% \quad (1)$$

118 Notes:  
 119 P = Eligibility percentage  
 120  $\sum X$  = Total score obtained  
 121  $\sum Xi$  = Maximum possible score  
 122

123 **Table 1. Validity Criteria**

Percentage	Validity Criteria
85.01%-100%	Considered highly valid and suitable for use without requiring revisions.
70.01%-85%	Categorized as sufficiently valid and appropriate for use with slight improvements.
50.01%-70%	Classified as less valid and in need of substantial revisions before implementation
0%-50%	Invalid and cannot be used

124  
 125 To verify the effectiveness of a self-developed digital comic learning medium themed on landslide disaster  
 126 mitigation, this study takes the magnitude of improvement in students' understanding before and after using  
 127 the developed learning medium as its core indicator. It adopts N-Gain analysis, which can measure this degree  
 128 of improvement, and its corresponding formula as the core basis for data analysis.

$$129 \quad N-Gain = \frac{Posttest - Pretest}{Maximum Score - Pretest} \quad (2)$$

130  
 131 A score of greater than 0.7 is included in the high category based on N-Gain criteria to percent increase in  
 132 students learning outcomes, Moderate scores from 0.3 to 0.7. These tend to be a fair, although about half the  
 133 students achieving better, between their expected and actual achievement levels. On the other hand, N-Gain <  
 134 0.3 is categorized as low, indicating a rise in students' understanding still has to be improved.

### 135 **3. Results and Discussion**

#### 136 **3.1. Result**

##### 137 **3.1.1. Analysis Phase**

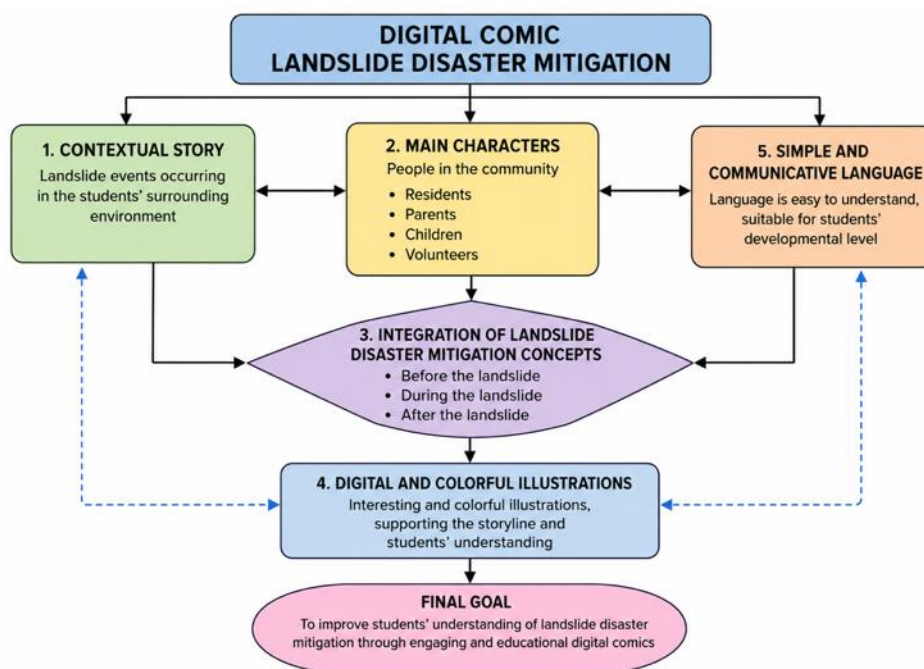
138 The analysis was accomplished via a review of documents, field observations, and interviews with the  
 139 principal and fifth-grade teachers at an elementary school. From the analysis results, disaster mitigation  
 140 material about landslides is already being taught in thematic learning and IPAS (Integrated Science and  
 141 Technology), but still not optimally implemented in the learning process. Results of the interviews suggest that

142 textbooks and teacher-centered instruction remained the primary approaches used in teaching. The  
 143 instructional media currently used have not been able to incorporate disaster literacy in a contextual and  
 144 appealing manner for students. Beyond that, the content is presented very abstractly and without supporting  
 145 imagery and thus students do not get a feel for causes, warning signs and mitigation steps relating to landslides.  
 146 The researcher also observed the learning activities and conducted teachers needs assessment. Observation  
 147 results indicated that whiteboards, speakers, and LCD projectors were available. Each teacher had been  
 148 provided with a laptop, though these were still rarely used in the learning process. Students had difficulty  
 149 understanding the learning material. The learning resources used consisted of textbooks and student  
 150 workbooks. The media used by teachers in the learning process included images of landslides and textbooks,  
 151 while the Chromebooks provided by the school and other digital media were rarely utilized in learning activities.

152 Analysis of students' answers on learning outcomes regarding environmental and disaster mitigation  
 153 materials found that more than 2/3, about 65% of students failed to meet the Minimum Competency Criteria  
 154 determined by the school. These results indicate that learning difficulties still occur which require the  
 155 development of teaching media so that students can understand better.

### 156 3.1.2. Design Phase

157 In the designing phase, it was created a digital comic integrating disaster literacy into to landslide  
 158 mitigation for elementary students, this was the product design, just before development (see Figure 1). This  
 159 comic was designed according to the results of needs analysis, the characteristics of elementary school students,  
 160 learning outcomes and principles of engaging interactive visual learning. The digital comic was designed with  
 161 several key components, namely a contextual story about a landslide event in the students' local community,  
 162 main characters consisting of local community members, integration of disaster mitigation concepts before,  
 163 during, and after a landslide, digital and colorful illustrations, and simple and communicative language  
 164 appropriate for the students' developmental level. In addition, the researchers also developed a storyboard, plot  
 165 outline, learning materials, and assessment instruments used in the product development process.



166  
167 **Figure 1. Comic Storyline**

### 168 3.1.3. Development Phase

169 The development phase of this study was conducted systematically to produce an educational digital comic  
 170 suitable for use in teaching landslide disaster mitigation in elementary schools. In this phase, the researcher  
 171 began to implement the product design developed in the design phase into a tangible product in the form of an  
 172 interactive digital comic that is engaging for elementary school students.

173 The developed product contains landslide mitigation material presented in the form of contextual visual  
 174 stories so that students can more easily understand disaster-related material through learning experiences  
 175 closely tied to their daily lives. The stories in the comic depict the surrounding environmental conditions prone  
 176 to landslides, early warning signs of the disaster, self-rescue actions, as well as mitigation steps before, during,

177 and after a landslide occurs. The characters in the comic are modeled after the local community surrounding the  
 178 students, thereby enhancing students' emotional engagement and interest in learning.

179 During the development process, the researchers designed several key components of the product,  
 180 including the development of a comic storyline aligned with disaster mitigation learning objectives, creating  
 181 comic characters and figures that are relatable to the lives of elementary school students, integrating landslide  
 182 mitigation material into the story's dialogue and illustrations, creating full-color digital illustrations using digital  
 183 design software, designing the layout of text, images, and panels. Examples of the digital comic pages developed  
 184 in this study are shown in Figure 2.



185 **Figure 2. Digital Comic Design**

187 After the initial product was developed, the next step was expert validation to determine the suitability of  
 188 the digital comic. Validation was conducted by three validators: a media expert, a content expert, and a  
 189 practitioner/user. The media expert assessed the integration, media design, and usability aspects of the digital  
 190 comic, and the results are presented in Table 2. The content expert evaluated the accuracy, thematic relevance,  
 191 language, and effectiveness of the disaster mitigation material, with the results shown in Table 3. Furthermore,  
 192 the practitioner/user assessed the appearance, content quality, practicality, and usability of the digital comic, as  
 193 presented in Table 4. A summary of the validation results from all validators is provided in Table 5, indicating  
 194 that the developed digital comic is highly valid and suitable for use in elementary school learning.

195 **Table 2. Media Expert Validation Results**

No	Evaluation Aspect	Score	Validity (%)
1	Integration	13	86%
2	Media Design	33	83%
3	Usability	8	80%
	Average Validity	54	83%

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197 **Table 3. Expert Validation of Content**

No	Evaluation Aspect	Score	Validity (%)
1	Content	26	86%
2	Thematic Relevance	18	90%
3	Language	8	80%
4	Effectiveness	14	93%
	Average Validity	54	87%

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199 **Table 4. Results of the Practitioner/User Survey**

No	Evaluation Aspect	Score	Validity (%)
1	Appearance	18	90%
2	Content	19	95%
3	Practicality and Usability	20	100%
	Average Validity	57	95%

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201 **Table 5. Summary of Expert Validation Results**

No	Validator	Validity (%)	Category
1	Media Expert	83%	Highly valid
2	Content Expert	87%	Highly valid
3	Practitioner/User	95%	Highly valid

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203 According to the validation results indicate that the developed educational digital comic was categorized  
 204 as "highly valid" for implementation in the learning process. The high validation scores indicate that the product  
 205 meets standards for appropriate content and media design, and instruction in elementary school. Still, the  
 206 validators gave a number of tips how to improve it making the product even better. The suggestions included  
 207 the following, rewording certain disaster terms to make them elementary school student-friendly, with images  
 208 on the first signs of a landslide, adjusting the spot of the text and images to make them more proportional at a  
 209 glance, modify it to have a more vibrant color palette appropriate for elementary grade school students and to  
 210 make it appeal visually.

211 To do so, the researcher revised the product by fixing parts that were still bad based on these inputs.  
 212 Updated language and images, comic book panel layout, color palette and visual design were all aspects that  
 213 were subsequently revised. After finishing the revision stage, it was developed into a digital comic for  
 214 implementation or field trial in order to see its practicality and efficacy as part of a learning process.

215 **3.1.4. Implementation Phase**

216 The initial validation of disaster literacy integrated in a digital comic product Being instead it's called the  
 217 implementation phase started. In this stage, the product was used in learning to analyze how feasible and  
 218 effective the developed learning medium is. It was carried out gradually, with each trial being comprised of  
 219 individual trials, small-group trials, and full-scale trials with fifth-grade elementary school students. Prior to  
 220 conducting the trial activities, the researchers produced appeal material, research instruments, observation  
 221 guidelines, student response questionnaires as well as pretest and posttest items used in this study. Teachers  
 222 were also given guidance on the ways to utilize the digital comic through a learning implementation system.

223 **3.1.4.1. Results of the Individual Pilot Study**

224 An individual pilot study was conducted with three fifth-grade elementary school students with high,  
 225 moderate, and low academic abilities. The selection of students with varying abilities aimed to determine the  
 226 readability, clarity of the material, and ease of use of the digital comic across different student characteristics.  
 227 During the pilot study, students were asked to read and use the digital comic independently under the  
 228 supervision of the researcher. Next, the students were asked to provide feedback through an evaluation  
 229 questionnaire covering aspects of media presentation, clarity of content, ease of use, and visual appeal.  
 230 Additionally, the researcher observed the students' responses and activities while they were using the learning  
 231 media.

232 Based on the results of individual trials, students responded positively to the digital comic that was  
 233 developed (see Table 6). Students were drawn to the illustrations, colors, and storyline presented. Additionally,  
 234 the use of simple language helped students understand the material on landslide mitigation more easily.  
 235 Although the comic received a "very good" rating, students also provided some feedback, such as increasing the  
 236 text size in certain sections and adding illustrations of self-rescue actions to make them clearer. Based on this  
 237 feedback, the researcher made minor revisions before proceeding to the small-group testing phase.

238 **Table 6. Results of the Individual Pilot Test**

Value Interval	Frequency	Percentage (%)
65-68	2	66.7%
69-72	0	0%
73-76	1	33.3%
N	3	
Mean	68	

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240 **3.1.4.2. Results of the Small-Group Pilot Test**

241 Following revisions in step 2, the researcher performed a small-group pilot test with 10 fifth-grade  
 242 students aged 10-11 years, consisting of 4 boys and 6 girls. The participants were recruited from a on slopes of  
 243 Mount Lawu, East Java, Indonesia, a region prone to landslides. The location was selected because it reflects the  
 244 environmental context addressed in digital comic. This pilot test sought to evaluate ideal use of digital comics  
 245 as a part of the learning process, and student interactions with the medium during collaborative classroom  
 246 exercises.

247 In this stage, the lesson was conducted using digital comics as the primary medium for delivering material  
 248 on landslide mitigation. Teacher guided the students in reading the comics, discussing the story's content,  
 249 identifying disaster mitigation steps, and answering questions related to the material studied. After the lesson  
 250 concluded, the students were asked to complete a feedback questionnaire regarding the use of the medium.

251 Results of a small pilot study suggest that digital comics would be feasible for educational use (see Table  
 252 7). Students seemed more engaged in the learning process, especially when analysing aspects of the story and  
 253 measures to mitigate disasters. Another reason that using digital comics helps student motivation, is the  
 254 material is delivered in such a engaging manner by way of illustrations and stories that relate directly to students  
 255 daily lives. Also, teachers say that comics improves students' understanding of previously challenging and  
 256 abstract material results indicated that the product was suitable for large-scale pilot-phase use.

257 **Table 7. Results of the Small-Group Pilot Test**

Value Interval	Frequency	Percentage (%)
65-68	3	30%
69-72	1	10%
73-76	4	40%
77-80	2	20%
N	10	
Mean	72.5	

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### 259 3.1.4.3. Results of the Large-Scale Pilot Study

260 In this phase, students completed a pretest which was administered prior to instruction in order to  
 261 measure their baseline knowledge of landslide mitigation. It then used the created digital comics for the learning  
 262 process. After the instructional activities were completed, students took a posttest to evaluate improvements in  
 263 their learning outcomes following the use of the digital comics. Results of the large-scale pilot test showed that  
 264 students achieved an average score of 88.43 (see Table 8).

265 **Table 8. Results of the Large-Scale Pilot Test**

Value Range	Frequency	Percentage (%)
80-84	6	17%
85-89	10	28%
90-94	9	26%
95-100	10	29%
N	35	
Mean	88.43	

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267 Table 9 shows that 10 students (29%) experienced a high level of improvement in learning outcomes,  
 268 while 25 students (71%) experienced a moderate level of improvement. The overall average N-Gain score was  
 269 0.6, indicating a moderate improvement in learning outcomes. This suggests that the use of digital comics is  
 270 quite effective in improving students' learning outcomes regarding landslide mitigation.

271 **Table 9. N<sub>gain</sub> Analysis**

Value	Criteria	N <sub>gain</sub>	
		Frequency	Percentage (%)
<g> ≥ 0.7	High	10	29
0.7 > <g> ≥ 0.3	Moderate	25	71
<g> < 0.3	Low	0	0
Total		35	100

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273 The researcher also measured student responses to the use of learning media. The results of the student  
 274 response questionnaire showed a percentage of 89% in the very positive category (see Table 10). Students  
 275 stated that digital comics made learning more interesting, enjoyable, easy to understand, and not boring. Overall,  
 276 the results of the implementation indicate that digital comics incorporating disaster literacy are: (1) suitable for  
 277 use in learning; (2) practical for use by teachers and students; (3) effective in improving student learning  
 278 outcomes; (4) capable of increasing the motivation and interest of elementary school students in learning about  
 279 landslide disaster mitigation.

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**Table 10. Results of the Student Response Questionnaire for Individual, Small-Scale, and Large-Scale Trials**

No	Question	Percentage		
		Individual Trial	Small-Scale Trial	Large-Scale Trial
1	I am interested in the visual appeal of the digital comics used	70%	70%	94%
2	I find the font type and size in the digital comics easy to read	80%	80%	85%
3	I can understand the material clearly because the images displayed are high-quality and supportive	80%	80%	97%
4	I find the background colors and text comfortable to look at	100%	100%	88%
5	I understand the presentation of the instructional material	90%	90%	85%
6	I find the sentences in the digital comics easy to understand and clear	100%	100%	94%
7	I consider the medium used appropriate for the learning material	90%	90%	94%
8	I can understand the language used in the digital comic	100%	100%	85%
9	I understand the spelling of the language used	100%	100%	85%
10	I can understand the material well after using the digital comic	100%	100%	94%
11	I can understand the instructions for using digital comics well	80%	80%	91%
12	I can access digital comics easily	90%	80%	94%
13	I feel that digital comics help me increase my interest in learning	90%	90%	91%
Total		1.168%	1.160%	1083%
Average		90%	89%	90%
Criteria		Very Positive	Very Positive	Very Positive
Average Response		89%		
Criteria		Very Positive		

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### 285 3.1.5. Evaluation Phase

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Based on the evaluation results, students responded very positively to the use of digital comics in landslide mitigation education. Students stated that the learning medium was engaging, easy to use, and helped them understand the material more clearly through colorful illustrations, contextual stories, and simple language. In addition, students appeared more active, focused, and enthusiastic throughout the learning process.

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In their comments professors and teachers alike were also very impressed as digital comics made the disaster mitigation material more tangible and less abstract than conventional textbooks. The medium in which the instruction were delivered was considered to be one that increased motivation, focused attention and participation among students. However, many made relevant points for improvement including clearer use of illustrations, larger font size and simplification of the narrative to help students to follow. Using this feedback, the researchers then finalized the visual presentation, layout and language used. Digital comic integrating disaster literacy was found appropriate, feasible and a potentially effective tool for landslide mitigation education in elementary schools.

### 298 3.2. Discussion

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The outcome of this development research was an educational medium in a digital comic form that integrated disaster literacy into landslide mitigation material for elementary school students. It is built based on the ADDIE models of Analysis, Design, Development, Implement and Evaluation. With the research results, the digital comic developed is feasible and practical and effective to use in learning. This study uniquely contributes to the creation of a digital comic for integrating content with contextual visual stories about landslide mitigation disaster literacy in elementary school learning based on the unique characteristics of elementary school students.

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Textbooks and lecture-based methods are still typically used in the field of disaster mitigation education only limited to elementary schools which forced students to have difficulty understanding abstract concepts (Afifah et al., 2022; Masturah et al., 2018). Meanwhile, other digital learning support tools such as Chromebooks, LCD projectors, and internet connectivity either have not been fully optimized in the learning process. The analysis result also showed that students who have not graduated from minimum competency standard on environmental and disaster topics are about 65%. This condition shows that innovative learning media need to be developed, which can help students understand their lessons concretely and fun. It is as in the opinion of Lestari et al., (2024) and Sugiarto et al., (2023) that learning media can improve the effectiveness of the teaching and learning process.

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Digital comics were developed by integrating visual elements, contextual narratives, and landslide mitigation material that is relevant to students' daily lives. The use of colorful illustrations, simple language, and characters that reflect the local environment helps students grasp the material more easily. This aligns with

318 Piaget's theory of cognitive development, which states that elementary school students are in the concrete  
319 operational stage and thus find it easier to understand material through visualization and real-world  
320 experiences. This view is supported by Hosler and Boomer (2011) who states that visual media can clarify  
321 abstract material by making it more concrete, thereby making it easier for students to understand the learning  
322 material.

323 In addition, integrating disaster literacy into digital comics helps students understand mitigation measures  
324 before, during, and after a landslide occurs. Presenting the material through contextual visual stories enables  
325 students to not only grasp the concepts theoretically but also understand the application of disaster mitigation  
326 in daily life. This is important because early disaster education can improve students' preparedness for disaster  
327 risks in their surrounding environment. (Septikasari & Ayriza, 2018) state that disaster education in elementary  
328 schools plays a crucial role in building students' knowledge and preparedness for disasters.

329 The validation results also showed that the digital comic received a "highly valid" rating from media  
330 experts, subject matter experts, and practitioners/users. The validation scores 83% as media experts, 87% as  
331 subject matter Experts, and As Practitioners/users 95% confirmed, these findings indicate that the content for  
332 content criteria, visual presentation, readability, suitability for elementary school students. Validators also  
333 offered many suggestions for improvement, including simplifying the terminology related to disasters, adding  
334 illustrations of landslide warning signs, and improving formatting of text and images. Product validation and  
335 revision are important stages in development research to produce a product that is fit for use in learning  
336 (Septikasari & Ayriza, 2018).

337 During the implementation phase, results from individual, small-group, and large-scale trials indicated  
338 that the digital comic is practical for use in learning. Students appeared more active, focused, and enthusiastic  
339 when using the learning medium. This was evident from student responses, which averaged 89% in the "very  
340 positive" category. The aspects that received high percentages indicate that students were interested in the  
341 visual presentation, ease of use, and clarity of the material presented in the digital comics. Engaging learning  
342 media can enhance students' motivation and interest in learning throughout the learning process (Zahra et al.,  
343 2023).

344 The results of the large-scale pilot study showed an improvement in student learning outcomes after using  
345 digital comics. The average N-Gain score of 0.6 falls into the moderate category, indicating that the medium is  
346 quite effective in improving students' understanding of landslide mitigation. Twenty nine percent of students  
347 showed a high improvement in learning outcomes, while the other 71% fell into the moderate category. This  
348 improvement in learning outcomes occurred because students gained visual and contextual learning  
349 experiences that helped them understand disaster mitigation concepts more concretely. This aligns with the  
350 opinion of Utomo (2023) (Utomo, 2023), who states that interactive learning media can enhance the  
351 effectiveness of learning and help students gain more meaningful learning experiences.

352 The findings of this study are also supported by previous research. Utomo (2023) demonstrated that the  
353 use of digital comics can enhance motivation and learning outcomes among elementary school students.  
354 Cunningham et al (2025) also indicated that visual story-based learning media helps students understand  
355 abstract concepts in a more concrete and engaging manner. Thus, the results of this study reinforce the finding  
356 that digital comics are effective for use in elementary school learning, particularly for disaster mitigation  
357 material.

358 During the evaluation phase, students and teachers provided very positive feedback regarding the use of  
359 digital comics in learning. Teachers stated that the learning medium helped explain material previously  
360 considered abstract in a more concrete way through illustrations and visual storytelling. Additionally, the use of  
361 digital comics increased students' attention, motivation, and participation during the learning process. This  
362 indicates that digital comic-based learning media can create a more interactive and enjoyable learning  
363 environment. This view is supported by Ndabaga et al., (2023), who states that visual media can help create  
364 more active, engaging, and effective learning.

### 365 3.3. Implications

366 The findings of this study suggest that elementary school teachers can utilize digital comics as an  
367 innovative alternative learning medium to enhance students' understanding of disaster mitigation from an early  
368 age. The use of digital media also supports 21st-century learning, which emphasizes the use of technology in the  
369 learning process. Furthermore, integrating disaster literacy into elementary school education is essential for  
370 improving students' preparedness for disaster risks in their surrounding environment.

### 371 3.4. Limitations

372 Nevertheless, this study still has limitations. The product trial was conducted at only one elementary  
373 school and was limited to landslide mitigation material; therefore, the study's findings cannot yet be widely

374 generalized. Furthermore, the developed media is still in the form of a simple digital comic and does not yet  
375 include audio features or interactive animations. The authors of this paper propose that an interactive learning  
376 application covering a wider range of disaster-related content can be developed in the future to enhance the  
377 appeal and practical effectiveness of learning. This article confirms that digital comics integrated with disaster  
378 literacy, when used as a teaching medium for landslide disaster risk reduction education in primary schools, are  
379 both feasible and effective. They can improve learning outcomes, and cultivate students' learning motivation,  
380 engagement, and disaster preparedness capacity.

#### 381 **4. Conclusion**

382 Digital comics incorporating disaster literacy in landslide mitigation materials are therefore appropriate  
383 and user-friendly, effective for use in elementary school education at the primary level based on the findings of  
384 this study. This media was designed by ADDIE model that allows students to more clearly contextualism the  
385 content through visual narratives of disaster mitigation materials, engaging illustrations and language patterns  
386 that are easy to understand. Digital comics have been shown through expert validation and pilot testing to  
387 enhance student motivation, engagement, and learning outcomes. Moreover, the implementation of disaster  
388 literacy in instructional media can help students comprehend and prepare to face landslides as early as possible.  
389 So, a new alternative medium of instruction which is now being explored in elementary schools are digital  
390 comics that can foster interactive and impactful learning experiences. Overcoming some disadvantages  
391 associated with traditional paper-based comics

#### 392 **Author Contributions**

393 All authors contributed equally to this paper. All authors have read and approved the final manuscript.

#### 394 **Funding**

395 No funding support was received.

#### 396 **Declaration of Conflicting Interests**

397 The authors declared no potential conflicts of interest with respect to the research, authorship, and/ or  
398 publication of this article.

#### 399 **Data Availability**

400 The datasets generated during and/ or analyzed during the current study are available from the  
401 corresponding author on reasonable request.

#### 402 **Declaration on AI Use**

403 The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of  
404 this manuscript.

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